IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH)

FOP FOR AASHTO T 310

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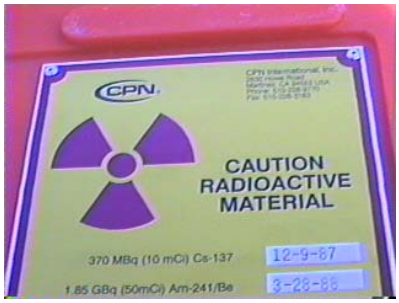
Checking deflection



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Caution!

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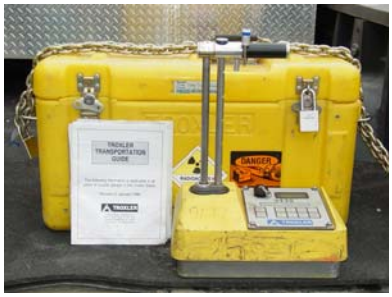

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Significance

The final in-place density of roadway embankment and base is critical to the quality and longevity of a highway project. Low-density material will lead to excessive deflection under load and/or permanent deformation.

This procedure provides a rapid, nondestructive technique for determining the in-place wet density and moisture content of soil, aggregate, and soil-aggregate mixes. The non-destructive nature of the test allows repetitive measurements to be made at a single test location between roller passes. The procedure is normally suitable from test depths of 50 mm (2 in.) to 300 mm (12 in.).

Scope

This procedure covers the determination of density, moisture content, and relative compaction of soil, aggregate, and soil-aggregate mixes in accordance with AASHTO T 310. This field operating procedure is derived from AASHTO T 310. The nuclear moisture-density gauge is used in the direct transmission mode.

Apparatus

- Nuclear density gauge with the factory matched standard reference block.
- Drive pin, guide / scraper plate, and hammer for testing in direct transmission mode.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.
- Radioactive materials information and calibration packet containing:
  - Daily Standard Count Log
  - Factory and Laboratory Calibration Data Sheet
  - Leak Test Certificate
  - Shippers Declaration for Dangerous Goods

Nuclear gauge

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  - Procedure Memo for Storing, Transporting and Handling Nuclear Testing Equipment.
  - Other radioactive materials documentation as required by local regulatory requirements.

- Sealable airtight containers and utensils for moisture content determinations.

Radiation Safety

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- This method does not purport to address all of the safety problems associated with its use. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating nuclear density gauges. Some agencies require the use of personal monitoring devices such as a thermo luminescent dosimeter or film badge. Effective instructions together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

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Calibration

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Calibrate the nuclear gauge as required by the agency. This calibration may be performed by the agency using manufacturer's recommended procedures or by other facilities approved by the agency. Verify or re-establish calibration curves, tables, or equivalent coefficients every 12 months.

Standardization

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1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day's testing.
2. Standardize the nuclear gauge at the construction site at the start of each day's work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations

established by the manufacturer of the gauge.

If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and or recalibrated.

3. Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer's Operators Manual.

Note 1: New standard counts may be necessary more than once a day. See agency requirements.

Overview

14 There are two methods for determining in-place determination of soil / soil aggregate

- Method A: Single Direction
- Method B: Two Directions.

Procedure

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1. Select a test location(s) randomly and in accordance with agency requirements. Test sites should be relatively smooth and flat and meet the following conditions:
   a) At least 10 m (30 ft) away from other sources of radioactivity
   b) At least 3 m (10 ft) away from large objects
   c) The test site should be at least 150 mm (6 in.) away from any vertical projection, unless the gauge is corrected for trench wall effect.
2. Remove all loose and disturbed material, and remove additional material as necessary to expose the top of the material to be tested.

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3. Prepare a flat area sufficient in size to accommodate the gauge. Plane the area to a smooth condition so as to obtain maximum contact between gauge and the material being tested. For Method B, the flat area must be sufficient to permit rotating the gauge 90 or 180 degrees about the source rod.

4. Fill in surface voids beneath the gauge with native fines passing the 4.75 mm (No. 4) sieve or finer. Smooth the surface with the guide plate or other suitable tool. The depth of the native fines filler should not exceed approximately 3 mm (1/8 in.).

5. Make a hole perpendicular to the prepared surface using the guide plate and drive pin. The hole shall be at least 50 mm (2 in.) deeper than the desired probe depth, and shall be aligned such that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. Remove the drive pin by pulling straight up and twisting the extraction tool.

6. Place the gauge on the prepared surface so the source rod can enter the hole without disturbing loose material.

7. Insert the probe in the hole and lower the source rod to the desired test depth using the handle and trigger mechanism.

8. Seat the gauge firmly by partially rotating it back and forth about the source rod. Ensure the gauge is seated flush against the surface by pressing down on the gauge corners, and making sure that the gauge does not rock.

9. Pull gently on the gauge to bring the side of the source rod nearest to the scaler/detector firmly against the side of the hole.

10. Perform one of the following as required by agency:

22 a. **Method A Single Direction**: Take a test consisting of the average of two, one minute readings, and record both density and moisture data. The two wet density readings should be within 32 kg/m^3 (2 lb/ft^3) of each other. The average of the two wet densities and moisture contents will be used to compute dry density.

23 b. **Method B Two Direction:** Take a one-minute reading and record both density and moisture data. Rotate the gauge 90 degrees or 180, pivoting it around the source rod. Reseat the gauge by pulling gently on the gauge to bring the side of the source rod nearest to the scaler / detector firmly against the side of the hole and take one-minute reading. (In trench locations, rotate the gauge 180 degrees for the second test.) Some agencies require multiple one-minute readings in both directions. Analyze the density and moisture data. A valid test consists of wet density readings in both gauge positions that are within 50 kg/m^3 (3 lb/ft^3). If the tests do not agree within this limit, move to a new location. The average of the wet density and moisture contents will be used to compute dry density.

Sampling Density site

24 11. If required by the agency, obtain a representative sample of the material, 4 kg (9 lb) minimum, from directly beneath the gauge full depth of material tested. This sample will be used to verify moisture content and / or identify the correct density standard. Immediately seal the material to prevent loss of moisture.

The material tested by direct transmission can be approximated by a cylinder of soil approximately 300 mm (12 in.) in diameter directly beneath the centerline of the radioactive source and detector. The height of the cylinder will be approximately the depth of measurement. When organic material or large aggregate is removed during this operation,

disregard the test information and move to a new test site.

12. To verify the moisture content from the nuclear gauge, determine the moisture content with a representative portion of the material using the FOP for AASHTO T 255/ T 265 or FOP for AASHTO T 217. If the moisture content from the nuclear gauge is within ±1% the nuclear gauge readings can be accepted. Retain the remainder of the sample at its original moisture content for a one-point compaction test under the FOP for AASHTO T 272, or for gradation, if required.

Note2: Example; A gauge reading of 16.8% moisture and oven dry or 17.7% are within the 1% requirements. Moisture correlation curves will be developed according to agency guidelines. These curves should be reviewed and possibly redeveloped every 90 days because of moisture source decay.

13. Determine the dry density by one of the following.

    a. From nuclear gauge readings, compute by subtracting the mass (weight) of the water (kg/m^3 or lb/ft^3) from the wet density (kg/m^3 or lb/ft^3) or compute using the % moisture by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

    b. When verification is required and the nuclear gauge readings cannot be accepted, the moisture content is determined by the FOP for AASHTO T 255/T 265 or FOP for AASHTO T 217, compute dry density by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

Percent Compaction

- Percent compaction is determined by comparing the in-place dry density as determined by this procedure to the appropriate agency density standard. For soil or soil-aggregate mixes, these

are moisture-density curves developed using the FOP for AASHTO T 99/ T 180. When using curves developed by the FOP for AASHTO T 99 /T 180, it may be necessary to use the FOP for AASHTO T 224 and FOP for AASHTO T 272 to determine maximum density and moisture determinations.

For coarse granular materials, the density standard may be density-gradation curves developed using a vibratory method such as AKDOT&PF's ATM 212, ITD's T 74, WSDOT's TM 606, or WFLHD's Humphrys.

See appropriate agency policies for use of density standards.

Calculation

Wet Density readings from gauge: 1963 kg/m^3 (121.6 lb/ft^3) 29

1993 kg/m^3 (123.4 lb/ft^3)

Ave: 1978 kg/m^3 (122.5 lb/ft^3)

Moisture readings from gauge: 14.2% & 15.4% = Ave 14.8%

Moisture content from the FOP's for AASHTO T 255 / T 265 or T 217: 15.9%

Moisture content is greater than 1% different so the gauge moisture cannot be used.

Calculate the dry density as follows:

$$\rho_d = \left(\frac{\rho_w}{w + 100} \right) \times 100 \quad \text{or} \quad \rho_d = \left(\frac{\rho_w}{\frac{w}{100} + 1} \right) \qquad 30$$

where

ρ_d = Dry density, kg/m^3 (lb/ft^3)

ρ_w = Wet density, kg/m^3 (lb/ft^3)

w = Moisture content from the FOPs for AASHTO T 255 / T 265 or T 217, as a percentage

$$\rho_d = \left(\frac{1978 kg/m^3 or 122.5 lb/ft^3}{15.9 + 100} \right) \times 100 \qquad \rho_d = \left(\frac{1978 kg/m^3 or 122.5 lb/ft^3}{\frac{15.9}{100} + 1} \right)$$

Corrected for moisture Dry Density: 1707 kg/m^3 (105.7 lb/ft^3)

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Report

Results shall be reported on standard forms approved by the agency. Include the following information:

- Location of test, elevation of surface, and thickness of layer tested
- Visual description of material tested
- Make, model and serial number of the nuclear moisture-density gauge
- Wet density
- Moisture content as a percent, by mass, of dry soil mass
- Dry density
- Standard density
- Percent compaction
- Name and signature of operator

Tips!

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- Check to make sure that:
  - base of gauge is clean prior to testing.
  - shutter block and assembly are free of debris and operating correctly.
  - source rod tip does not have a build up of material on end.

  - gauge is reading the proper position of the source rod when it is indexed, and that it has been seated correctly.
  - the hole into which the source is lowered is at least 50 mm (2 in.) deeper than the indexed position of the source rod.
  - surface is flat and the gauge does not rock.
  - surface has been properly prepared using filler material.
- Make sure battery is charged before starting work

REVIEW QUESTIONS

1. Describe the calibration and standardization process.

2. What precautions must be taken in selecting a test location?

3. Describe the procedure leading up to the taking of test measurements.

4. What is the difference between Method A and Method B?

5. What is the purpose of determining moisture content following the FOP for AASHTO T 255/T 265 or the FOP for AASHTO T 217?

PERFORMANCE EXAM CHECKLIST

IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH) FOP FOR AASHTO T 310

Participant Name _____ Exam Date _____

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

Procedure Element	Trial 1	Trial 2
1. Gauge turned on 10 to 20 minutes before use?	_____	_____
2. Calibration verified?	_____	_____
3. Standard count taken and recorded in accordance with manufacturer's instructions?	_____	_____
4. Test location selected appropriately 10 m (30 ft) from other radioactive sources, 3 m (10ft) from large objects, 150 mm (6 in) away from vertical projections?	_____	_____
5. Loose, disturbed material removed?	_____	_____
6. Flat, smooth area prepared?	_____	_____
7. Surface voids filled with native fines to 3 mm (1/8 in) maximum thickness?	_____	_____
8. Hole driven 50 mm (2 in) deeper than probe depth?	_____	_____
9. Gauge placed, probe placed, and source rod lowered without disturbing loose material?	_____	_____
10. Method A:		
a. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
b. Two, one-minute reading taken; wet density within 32 kg/m^3 (2 lb/ft^3)?	_____	_____
c. Density and moisture data averaged?	_____	_____
11. Method B:		
a. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
b. A minimum of a one-minute reading taken; density and moisture data recorded?	_____	_____
c. Gauge turned 90° or 180° (180° in trench)?	_____	_____

OVER

Procedure Element	**Trial 1**	**Trial 2**
d. Gauge firmly seated, and gently pulled so that the source rod is against the side of the hole toward the scaler / detectors?	_____	_____
e. A minimum of a one-minute reading taken; density and moisture data recorded?	_____	_____
f. Wet densities within 50 kg/m^3 (3 lb/ft^3)?	_____	_____
g. Density and moisture data averaged?	_____	_____
12. Representative sample (4 kg or 9 lbs) obtained from test location?	_____	_____
13. Sample sealed immediately to prevent moisture loss?	_____	_____
14. Moisture content determined using FOP's for AASHTO T 255/T 265 or AASHTO T 217?	_____	_____
15. Dry Density calculated using proper moisture content?	_____	_____

Comments: First attempt: Pass ☐ Fail ☐ Second attempt: Pass ☐ Fail ☐

Examiner Signature _____WAQTC #:_____